

$K_s^0 K_s^0$ correlations in 7 TeV pp collisions from the ALICE experiment at the LHC

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Abstract. Identical neutral kaon pair correlations are measured in 7 TeV pp collisions in the ALICE experiment. $K_s^0 K_s^0$ correlation functions are formed in 3 multiplicity \times 4 k_T bins. The femtoscopic kaon source parameters R_{inv} and λ are extracted from these correlation functions by fitting a femtoscopy \times PYTHIA model to them, PYTHIA accounting for the non-flat baseline found in pp collisions. Source parameters are obtained from a fit which includes quantum statistics and final-state interactions of the a_0/f_0 resonance. $K_s^0 K_s^0$ correlations show a systematic increase in R_{inv} for increasing multiplicity bin and decreasing R_{inv} for increasing k_T bin as seen in $\pi\pi$ correlations in the pp system, as well as seen in heavy-ion collisions. Also, $K_s^0 K_s^0$ correlations are observed to smoothly extend this $\pi\pi$ R_{inv} behavior for the pp system up to about three times higher k_T than the k_T range measured in $\pi\pi$ correlations.

1. Introduction

In this proceedings we present preliminary results from a $K_s^0 K_s^0$ femtoscopy study by the ALICE experiment [1] in 7 TeV pp collisions from the CERN LHC. The main motivations to carry out $K_s^0 K_s^0$ femtoscopic studies to augment the usual identical charged $\pi\pi$ femtoscopic studies are 1) to extend the k_T range of the charged $\pi\pi$ studies, 2) since K_s^0 is uncharged, it is not necessary to apply a final-state Coulomb correction to the pairs as is necessary for charged $\pi\pi$ pairs, and 3) one can in principle obtain complementary information about the collision interaction region by using different types of mesons. Previous $K_s^0 K_s^0$ studies have been carried out in LEP e^+e^- collisions [2, 3, 4], HERA ep collisions [5] and RHIC Au-Au collisions [6]. Due to statistics limitations, a single set of femtoscopic source parameters, i.e. R_{inv} and λ , was extracted in each of these studies. To our knowledge, the present study is the first femtoscopic $K_s^0 K_s^0$ study to be carried out a) in pp collisions and b) in more than one multiplicity and k_T bin.

2. Experimental details and results

K_s^0 identification and momentum determination were carried out with particle tracking in the ALICE Time Projection Chamber (TPC) and ALICE Inner Tracking System (ITS) [1]. The decay channel $K_s^0 \rightarrow \pi^+ \pi^-$ was used for particle identification. Figure 1 shows an invariant mass plot of candidate K_s^0 vertices for all event multiplicities and k_T along with a Gaussian + quadratic fit to the data. A vertex was identified with a K_s^0 if the invariant mass of the candidate $\pi^+ \pi^-$ pair associated with it fell in the

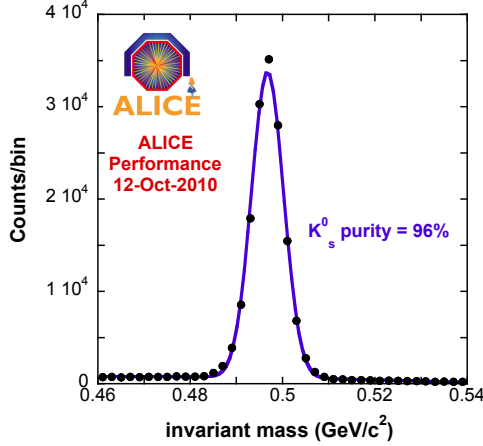


Figure 1. K_s^0 invariant mass peak.

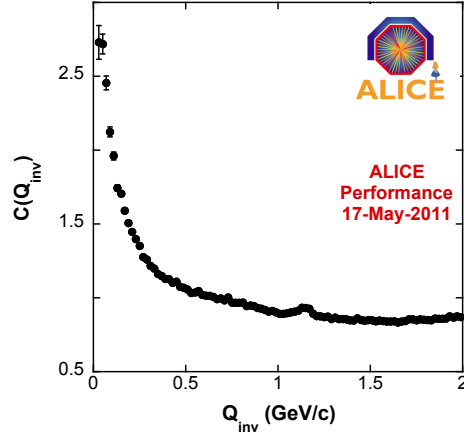


Figure 2. $K_s^0 K_s^0$ Q_{inv} correlation function for all multiplicity and k_T .

range 0.490-0.504 GeV/c^2 . As seen in Figure 1, the K_s^0 purity in this case is found to be 96%. K_s^0 purities of similar values are also found in the other multiplicity and k_T bins used in this study.

Figure 2 shows a $K_s^0 K_s^0$ correlation function in the invariant momentum difference variable $Q_{inv} = \sqrt{Q^2 - Q_0^2}$, where Q and Q_0 are the 3-momentum and energy differences between the two particles respectively, for all multiplicity and k_T . The three main features seen in this correlation function are 1) a well-defined enhancement region for $Q_{inv} < 0.3 \text{ GeV}/c$, 2) a non-flat baseline for $Q_{inv} > 0.3 \text{ GeV}/c$ and 3) a small peak at $Q_{inv} \approx 1.15 \text{ GeV}/c$. Considering feature 3) first, fitting a quadratic + Breit-Wigner function to the invariant $K_s^0 K_s^0$ mass (m_{inv}) distribution around this peak, where $m_{inv} = 2\sqrt{(Q_{inv}/2)^2 + m_{K_{0s}}^2}$, we obtain a mass of $1518 \pm 1 \text{ MeV}/c^2$ and width (Γ) of $67 \pm 9 \text{ MeV}/c^2$. Comparing with the Particle Data Group meson table [7], this peak is a good candidate for the $f_2'(1525)$ meson. This would be the first observation of the decay of this meson into the $K_s^0 K_s^0$ channel in pp collisions. In order to disentangle the non-flat baseline from the low- Q_{inv} femtoscopic enhancement, PYTHIA [8] was used to model the baseline. Both Gaussian and quadratic fits were made to PYTHIA-generated $K_s^0 K_s^0$ correlation functions for each multiplicity- k_T bin studied, and these fits were then used to define the baseline in fitting the femtoscopic function to the experimental correlation functions. PYTHIA with the Perugia-0 tune [9] is found to describe reasonably well the dependence of the baseline shape of the $K_s^0 K_s^0$ correlation function on multiplicity- k_T bin in the Q_{inv} fitting range used of 0-1 GeV/c . Using both the Gaussian and quadratic PYTHIA fits helped to define the systematic error of this approach, as well as adding to the systematic error estimate a $\pm 10\%$ uncertainty in the fit parameters due to the uncertainty in using PYTHIA to estimate the baseline.

$K_s^0 K_s^0$ correlation functions in Q_{inv} were formed from the data in 12 bins: 3 event multiplicity (1-11, 12-22, ≥ 23) bins \times 4 k_T (0.4-0.8, 0.8-1.1, 1.1-1.4, $\geq 1.4 \text{ GeV}/c$) bins. The femtoscopic variables R_{inv} and λ were extracted in each bin by fitting the experimental correlation function divided by the PYTHIA baseline shape by the Lednicky parameterization [6] based on the model by R. Lednicky and

V.L. Lyuboshitz [10]. This model takes into account both quantum statistics and strong final-state interactions from the a_0/f_0 resonance which occur between the $K_s^0 K_s^0$ pair. The K_s^0 spacial distribution is assumed to be Gaussian with a width R_{inv} in the parameterization and so its influence on the correlation function is from both the quantum statistics and the strong final-state interaction. This is the same parameterization as was used by the RHIC STAR collaboration to extract R_{inv} and λ from their $K_s^0 K_s^0$ study of Au-Au collisions [6]. Figure 3 shows a sample experimental $K_s^0 K_s^0$ correlation function divided by the PYTHIA quadratic baseline fit for the multiplicity 1-11 and k_T 0.4-0.8 GeV/c bin. Also shown are fits with the Lednicky parameterization and for comparison a usual Gaussian model. As seen, the R_{inv} and λ parameters from the Lednicky fit are $\sim 30\%$ and $\sim 50\%$ smaller, respectively, than those extracted from the Gaussian model fit. The RHIC STAR experiment saw $\sim 20\%$ reductions in these parameters in Au-Au collisions compared with a Gaussian model fit [6], the smaller effect being expected for a larger K_s^0 source size since the strong final-state interactions are reduced in that case by geometry [10].

Figures 4 and 5 present the results of this study for λ and R_{inv} parameters extracted by fitting the Lednicky parameterization to the $K_s^0 K_s^0$ correlation function in each of the 12 bins. Statistical + systematic errors are shown. The largest contribution to the error bars in all cases is due to the $\pm 10\%$ systematic uncertainty applied to the PYTHIA baseline fit parameters as discussed above. The k_T dependence of λ is seen in Figure 4 to be mostly flat with λ lying at an average level of $\sim 0.5 - 0.6$, similar to that found in the ALICE $\pi\pi$ results for 7 TeV pp collisions [11]. There is also a slight tendency seen for λ to be larger in the smaller multiplicity bins. Figure 5 plots R_{inv} vs. both k_T and m_T . Also shown for comparison are R_{inv} parameters extracted in the same event multiplicity bins from a $\pi\pi$ femtoscopic study by ALICE [11] in 7 TeV pp collisions. The $K_s^0 K_s^0$ results for R_{inv} suggest a slight tendency for R_{inv} to decrease with increasing k_T (or m_T) and to increase for increasing event multiplicity bin as also seen in the ALICE $\pi\pi$ results for 7 TeV pp collisions and in heavy-ion collisions [12]. Comparing with $\pi\pi$, the $K_s^0 K_s^0$ results for R_{inv} extend the covered range of k_T to ~ 2 GeV/c, which is about three times larger than for $\pi\pi$. It is also seen in Figure 5 that there is no discontinuity for the k_T and m_T dependences of R_{inv} between $\pi\pi$ and $K_s^0 K_s^0$.

The author wishes to acknowledge financial support from the U.S. National Science Foundation under grant PHY-0970048, and to acknowledge computing support from the Ohio Supercomputing Center.

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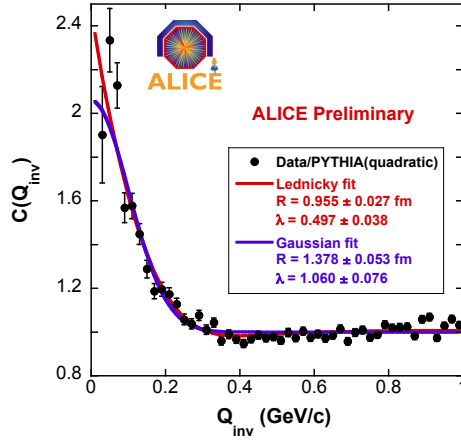


Figure 3. $K_s^0 K_s^0$ correlation function divided by the PYTHIA quadratic baseline fit for the multiplicity 1-11 and k_T 0.4-0.8 GeV/c bin with femtoscopic fits.

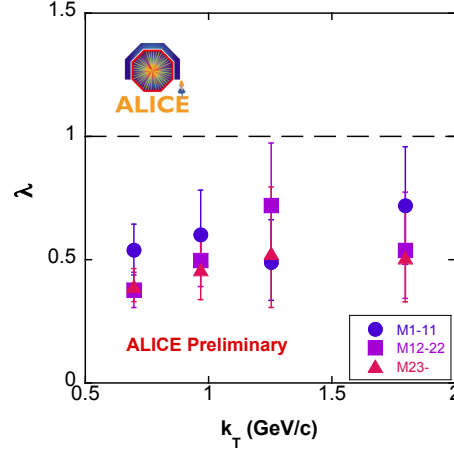


Figure 4. λ parameters extracted by fitting the Lednický parameterization to the $K_s^0 K_s^0$ correlation function in each of the 12 bins. Statistical + systematic errors are shown.

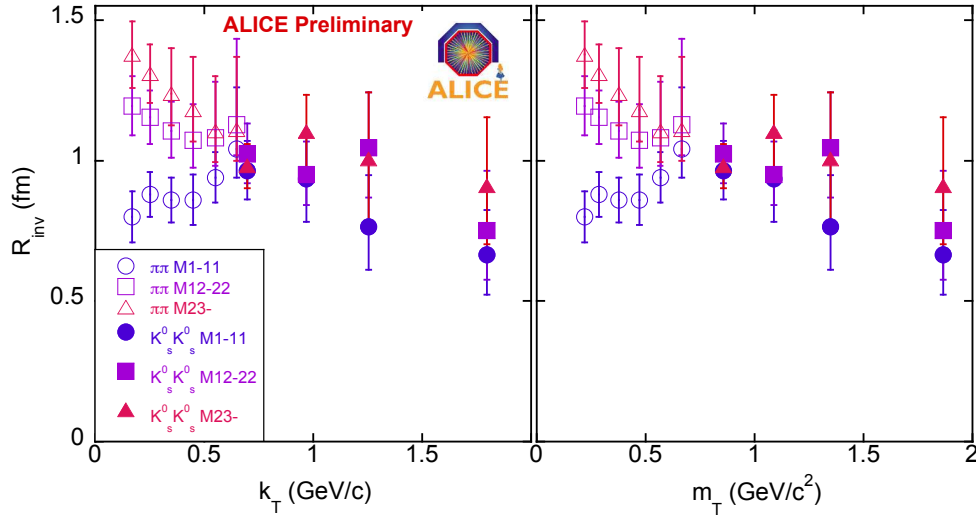


Figure 5. R_{inv} radius parameters extracted by fitting the Lednický parameterization to the $K_s^0 K_s^0$ correlation function in each of the 12 bins vs. k_T and m_T . Also shown for comparison are R_{inv} parameters extracted in the same event multiplicity bins from a $\pi\pi$ femtoscopic study by ALICE [11] in 7 TeV pp collisions. Statistical + systematic errors are shown.